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DAY TASK FORCE STUDY VOLUME I EXECUTIVE SUMMARY  
CHICAGO O'HARE INTERNATIONAL AIRPORT

July 1976

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# DELAY TASK FORCE STUDY.

## Volume I Executive Summary.

Chicago O'Hare International Airport



July 1976

PREPARED THROUGH JOINT EFFORT  
OF

FEDERAL AVIATION ADMINISTRATION  
CHICAGO DEPARTMENT OF AVIATION  
AIRLINES SERVING O'HARE

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# PREFACE

This study of air traffic delay at Chicago O'Hare International Airport, its causes and potential solutions, has identified no panacea to the problem in the present or future. However, the study does outline a comprehensive program of delay reduction measures which, if implemented, has the potential to dramatically reduce the current level and costs of delay. The program will also provide significant future delay reduction benefits regardless of the future air traffic control environment. The potential cost savings outlined are not intended to represent absolutes but rather to point out the most productive directions in which to focus industry action.

The study was conducted from December 1974 through June 1976 by a Task Force composed of representatives of the Federal Aviation Administration, the airlines serving O'Hare and the City of Chicago's Department of Aviation. The FAA provided the support of its Washington technical organization and consultant support as required from the Mitre Corporation and Peat, Marwick, Mitchell & Company. The Department of Aviation provided the continuous technical and editorial support of Landrum & Brown, airport consultants.

During the study, several of the delay reduction concepts identified by the Task Force have been tested by the study sponsors with results which parallel those identified in the Task Force evaluations, lending additional credence to the concepts.

This publication is a summary version of the final Task Force report which is comprised of three volumes: this Executive Summary, a Technical Report detailing the analyses which led to the recommendations, and a volume of Technical Appendices containing the data and the methodology used in this study.

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# INTRODUCTION

## background

In recent years, runway capacity has steadily declined at the nation's airports. Noise restrictions and wake vortex separation standards have resulted in significant increases in delay and delay related fuel consumption. The high cost of fuel has dramatically aggravated the economic effect of increased fuel consumption.

The development of new metropolitan airports to augment system capacity and reduce delay is difficult, as is the incremental expansion of existing facilities. It has become clear that continued provision of satisfactory air transportation service will require the aviation industry to concentrate its effort on achieving highest efficiency of the existing airport system. In order to achieve highest efficiency and to identify future requirements in practical terms, a need for quantitative system performance data at major airports was perceived. Such data would permit wise management decisions on optimum airport use strategies, runway, facility and equipment expenditures, and research and development priorities. The O'Hare Delay Task Force Study provides data for such management decisions at Chicago.

Establishment of a local Task Force was an outgrowth of Federal Aviation Administration (FAA) and Air Transport Association (ATA) concern with capacity and delay at the nation's major airports. A 1974 FAA report on airport capacity furnished considerable insights to capacity related operational problems at eight of the country's major airports; however, it was felt that its findings should be tested by the persons directly involved in operation and use of the airports. Therefore, in late 1974 the FAA established an ad hoc working group with the primary purpose of developing an action plan to reduce airport delays and identify development options for implementation or further study at ten major airports. It was anticipated that recommendations developed jointly would form a basis of support for individual management decisions by each participating group. The net result of these joint recommendations was envisioned to be a coordinated series of further actions whose combined effort would be to reduce delay substantially.

O'Hare International Airport, which annually processes approximately nine percent of the nation's air passengers, is experiencing significant delay related costs:

- \$44.3 million to aircraft operators
- 67 million gallons of fuel
- 4.6 million hours of passenger delays

For this reason, in early coordination meetings the Great Lakes Region FAA, FAA Washington, and the ATA decided to focus initial delay reduction efforts on Chicago O'Hare International Airport.

The following pages summarize the Objectives, Scope and Key Recommendations of the study. The remaining portion of this executive summary expands upon the study findings which support these recommendations.

## objectives

Considering O'Hare's escalating delays and their cost implications, the Task Force agreed upon four objectives to guide the analyses of present and future operations. These objectives were:

- To determine current capacity and delay levels and to identify causes of aircraft delay associated with operations in the airspace/airfield and apron/gate systems.
- To determine the potential delay reduction benefits of alternate air traffic control (ATC) procedural, airport use policy, and facility development options in the current and future time periods.
- To determine the potential capacity increase and delay reduction benefits of proposed future air traffic control (ATC) system improvements.
- To determine relationships between air traffic demand and delay in the current and future time periods as an aid in establishing acceptable air traffic movement levels.

## scope

All analyses focused on means for increasing facility operating efficiency and reducing delay through procedural adjustments, airport-use policy changes, and/or airport development actions. Analyses were primarily directed towards operations in the airspace/airfield system. Limited studies were conducted for the apron/gate system. O'Hare's groundside elements, consisting of the terminals, concourse, ground access, and automobile parking areas were not examined. Groundside problems are important and will be addressed in the on-going Chicago O'Hare Master Plan Study.

While environmental implications were recognized in developing recommendations, assessment of environmental impact was beyond the scope of the Task Force study. A current master plan study of the City's three airports, being conducted under the FAA Planning Grant Program, provides a convenient vehicle to accomplish the full environmental, social, and economic evaluation required for actions affecting the environment. Further, the master plan will include an exhaustive evaluation of those items beyond the scope of this study, such as the role of each airport in the Chicago system, terminal facility expansion, construction of new taxiways, runways or runway extensions, parking, roadway, and other access improvements, etc., resulting in a balanced plan for future facility improvement. The analyses and information developed by the Task Force provide basic input to the master plan and an excellent basis for initiating further study.

## methodology

The study was conducted using a simulation model which reflects the observed variability in system operations. This model was validated against real world throughput and delay data and then employed to quantify the benefits of the alternative delay reduction options identified by Task Force participants. A set of model input parameters was structured which characterized each option to be modeled. The results of the model experiments were then compared to control or baseline experiments and the delay reduction potential assessed.

### APPROACH CONTROL AIRSPACE

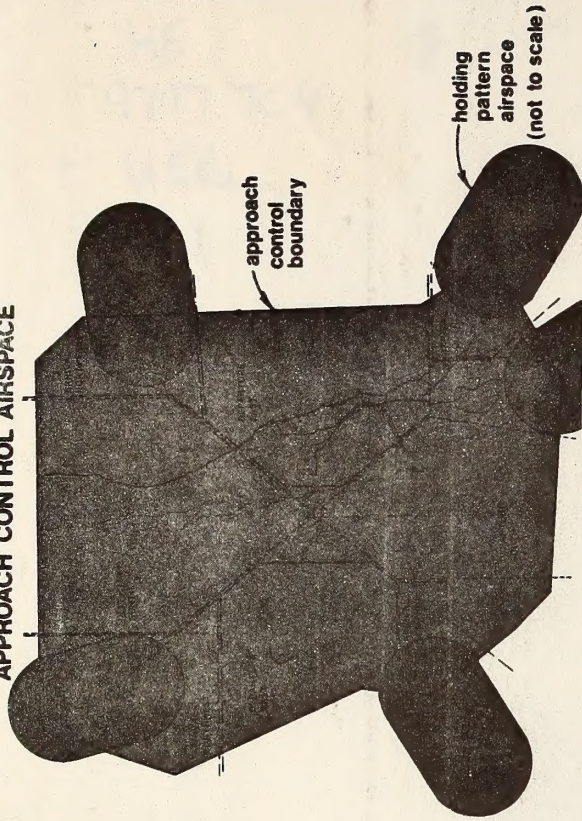


Exhibit 1

### O'Hare Terminal Area Airspace

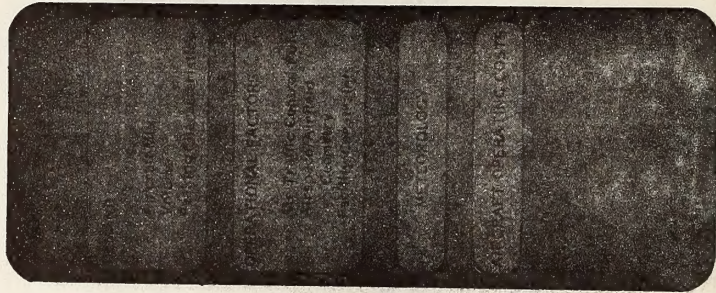


Exhibit 2

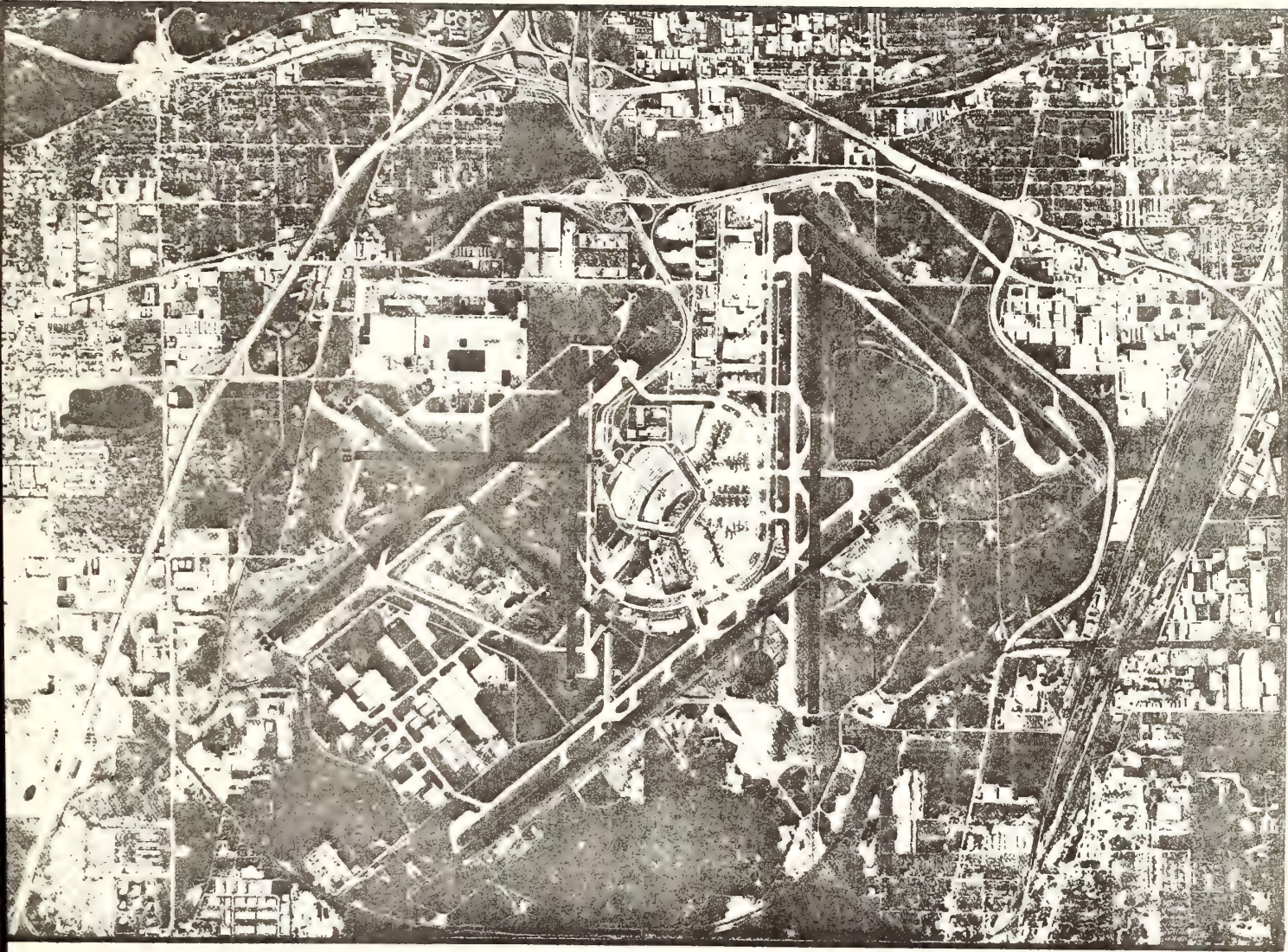


Exhibit 3

O'Hare International Airport

# KEY RECOMMENDATIONS

## air traffic operating strategy

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- DEVELOP AND IMPLEMENT AN AIRSPACE/AIRFIELD MANAGEMENT PLAN WHICH UTILIZES OPTIMAL RUNWAY CONFIGURATION (COMBINATION OF RUNWAYS IN USE) SELECTION TO MINIMIZE DELAY.
- DEVELOP AND IMPLEMENT A REAL-TIME DELAY INFORMATION SYSTEM FOR USE IN SELECTION OF OPTIMAL RUNWAY CONFIGURATIONS AND CONTROL OF TRAFFIC VOLUME.
- IMMEDIATELY IMPLEMENT PROCEDURES TO REDUCE SEPARATIONS WHEN EXISTING EQUIPMENT INDICATES WAKE VORTICES ARE NOT A PROBLEM.

POTENTIAL COST SAVINGS  
\$11,000,000 - \$18,000,000

## management of demand

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- ENFORCE EXISTING FAR 93 QUOTA RULE.
- ASSESS THE COSTS OF CHANGES IN THE LEVEL AND DISTRIBUTION OF DEMAND AS A BASIS FOR RE-EVALUATION OF AIRLINE SCHEDULING POLICY AND/OR ADJUSTMENT OF THE CURRENT QUOTA REGULATION.
- REFINE FLOW CONTROL PROCEDURES CONTROLLING O'HARE TRAFFIC UNDER ABNORMAL OPERATING CONDITIONS IN ORDER TO LIMIT DELAYS.

POTENTIAL COST SAVINGS  
\$3,000,000 - \$13,000,000

## airfield improvements

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- PLAN AND COORDINATE AIRFIELD CONSTRUCTION TO MINIMIZE DELAY.
- IMPLEMENT SPECIFIC PHYSICAL IMPROVEMENTS.
  - Taxiway exits on runways 22R and 14L
  - Relocate existing arrival holding apron in the D, E, and F concourse area
  - Construct additional arrival holding apron in the H and K concourse area.

POTENTIAL COST SAVINGS  
\$2,000,000 - \$5,000,000

## future atc technology

---

POTENTIAL COST SAVINGS  
\$13,000,000 - \$47,000,000

- EXPEDITE IMPLEMENTATION OF ADVANCED EQUIPMENT AND PROCEDURES TO ACHIEVE REDUCED INTRAIL SEPARATION UNDER ALL METEOROLOGICAL CONDITIONS WHICH ELIMINATE WAKE VORTEX IMPACT.
- STEP-UP EFFORTS TO PROVIDE WORKABLE AUTOMATION AIDS TO THE CONTROLLER IN MANAGING TERMINAL TRAFFIC.
- STEP-UP EFFORTS TO PROVIDE IMPROVED AIRPORT SURFACE SURVEILLANCE EQUIPMENT.
- UNDERTAKE INNOVATIVE RESEARCH AND DEVELOPMENT TO ACHIEVE ADDITIONAL REDUCTIONS IN OPERATIONAL SEPARATION STANDARDS.
- FAA TOP MANAGEMENT SHOULD FORMULATE MANAGEMENT MECHANISMS TO ASSURE PRACTICAL USER PAYOFF OF THE RESEARCH AND DEVELOPMENT PROGRAM.

## additional study

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- PERFORM ENVIRONMENTAL IMPACT ASSESSMENT, WHERE APPROPRIATE, OF ACTION ITEMS DESCRIBED IN THE STUDY.
- CONDUCT AN AIRSPACE ANALYSIS TO IDENTIFY MEANS TO REDUCE O'HARE'S AIR TRAFFIC INTERACTION WITH OTHER AREA AIRPORTS.
- INCLUDE A DETAILED EVALUATION OF FUTURE DEMAND/DELAY RELATIONSHIPS, FACILITY IMPROVEMENTS, AND ENVIRONMENTAL IMPACT IN THE O'HARE MASTER PLAN STUDY.

# IMPLEMENTATION OF RECOMMENDATIONS

An aggressive program of follow-up and implementation of the recommendations of this study is required to realize the potential delay reduction benefits identified. The program will be difficult, especially because it will require the full participation and cooperation of the airline industry, the City of Chicago, and the FAA. This is an organizational problem and new organizational forms must be devised to carry on the work. One such organizational form might be the appointment of a standing committee of representatives of the FAA, City of Chicago, and appropriate user groups to foster implementation of the study findings.

Notwithstanding the fact that O'Hare is one of the most extensively studied airports in the world, and notwithstanding the substantial FAA investment in study and development of third generation ATC hardware, this study is the first to comprehensively identify the magnitude of O'Hare system delay costs and to identify the cost payoff of application of ATC equipment improvements in terms that are meaningful to the system's users.

The computer simulation techniques employed by the Task Force are not new. However, it was apparent during this study that, despite their substantial potential for illuminating the consequences of alternative system improvement options, the FAA does not possess a sufficient technical resource for field-useable and actionable operations analysis upon which the industry can draw. The FAA needs to give higher priority to the acquisition and application of practical operations analysis and management science skills in its operations improvement and resource allocation process.

It is recognized that the possible environmental implications of implementing the items in this report may require detailed study. While many items could possibly have little or no environmental impact, any possible impact should be given careful consideration before making the decision to proceed.

TOP MANAGEMENT, UNDER FAA LEADERSHIP, SHOULD GIVE CONSIDERATION TO THE BROAD ORGANIZATIONAL AND OPERATIONAL IMPLICATIONS OF THIS STUDY, TAKING IMMEDIATE STEPS TO FORMULATE NEW MECHANISMS FOR IMPLEMENTING THE O'HARE RECOMMENDATIONS.

ENVIRONMENTAL IMPACT ASSESSMENTS SHOULD BE PERFORMED, WHERE REQUIRED BY THE NATIONAL ENVIRONMENTAL POLICY ACT, IN ORDER TO EXPEDITE IMPLEMENTATION OF THE ACTIONS RECOMMENDED IN THIS STUDY.

# SUMMARY OF STUDY

## current system performance

The first objective was to determine the performance characteristics of the airfield. Capacity, throughput, and delay were selected as performance measures. The initial finding was that, as applied to an airport, these terms and their interrelationships are often misunderstood and subsequently misused in the aviation industry. Therefore, very careful and precise definitions were adopted — a thorough understanding of these definitions is required if the findings and recommendations of this report are to be understood.

**Airfield Capacity** is the maximum number of aircraft operations (takeoffs and landings) which may be processed, irrespective of delay, in a given time at an airport under specific conditions of:

- airspace constraints,
- ceiling and visibility conditions,
- runway layout and use,
- aircraft mix,
- percent arrivals,
- exit taxiway locations, and
- system variability.

Airfield capacity is a calculated value expressed on an hourly or an annual basis. Hourly airfield capacity is generally calculated for specific combinations of runways in use (called a configuration), two of which are illustrated for O'Hare. On the surface, airfield capacity seems a simple concept. However, confusion begins when one seeks to attach a number to the word "capacity" as a descriptor of the airport under some specific set of conditions.

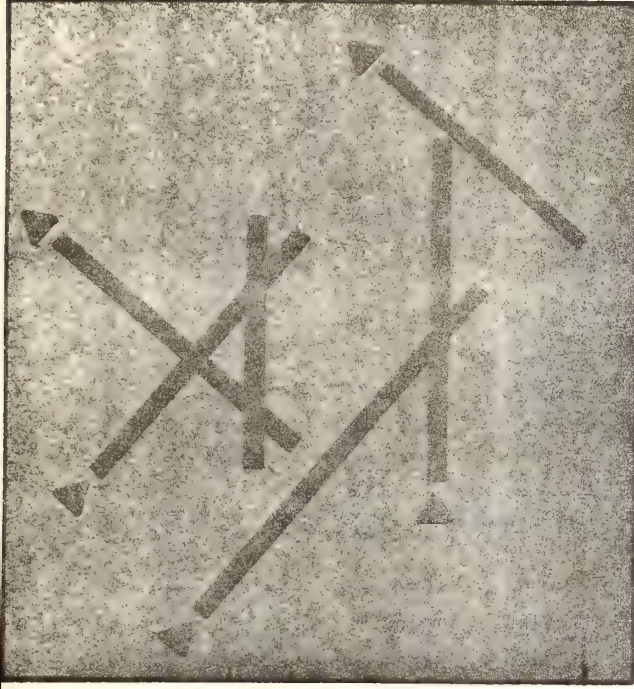


Exhibit 4

Typical Three Arrival Runway Configuration

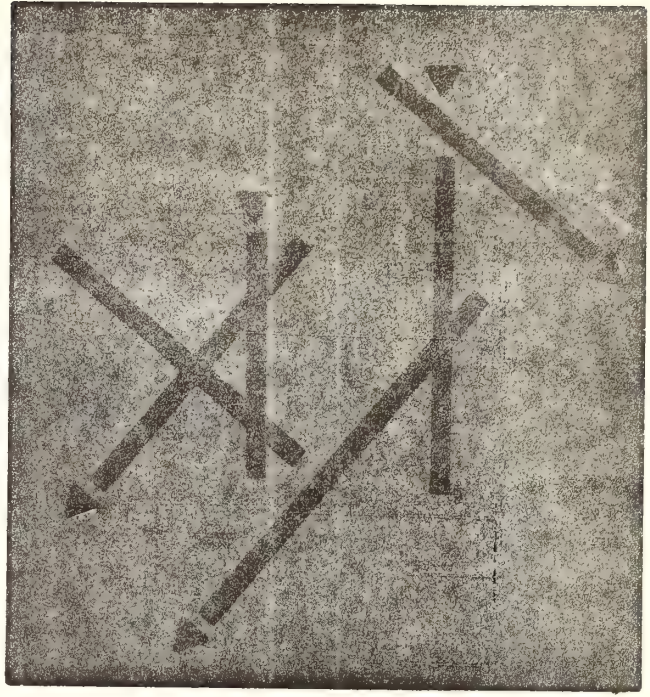


Exhibit 5

CAPACITY SHOULD BE USED ONLY TO INDICATE A MAXIMUM MOVEMENT LEVEL FOR A RUNWAY CONFIGURATION UNDER SPECIFIC CONDITIONS.

As is illustrated for two of O'Hare's commonly used runway configurations, capacity varies widely with changes in a single operating condition. Further, the degree of change in capacity differs between the runway configurations with identical changes in the operating condition.

This indicates that, in general, capacity must be considered a "point estimate" representative of a specific combination of operating conditions. Nevertheless, it is an indicator of airfield performance capability if its limitations are understood.

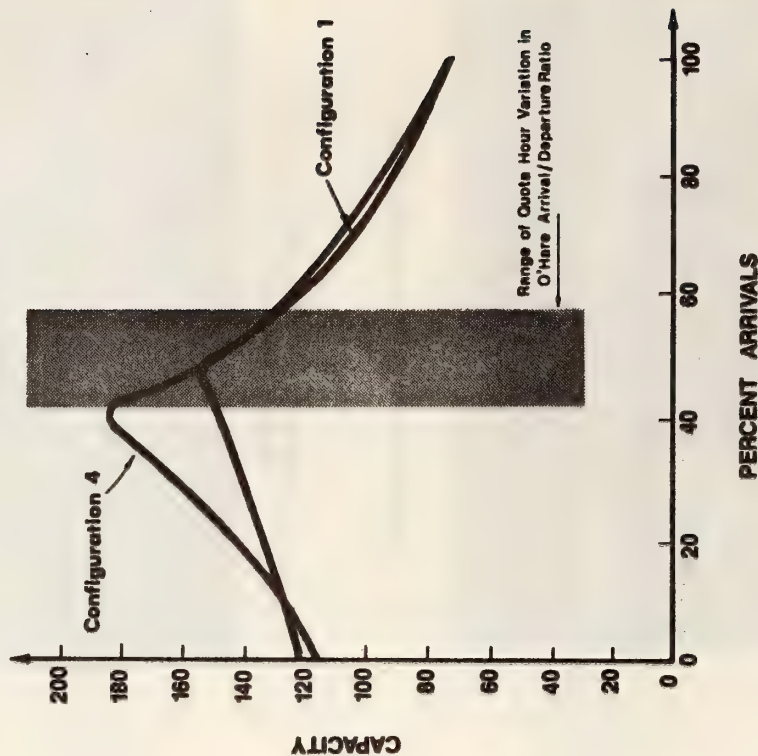
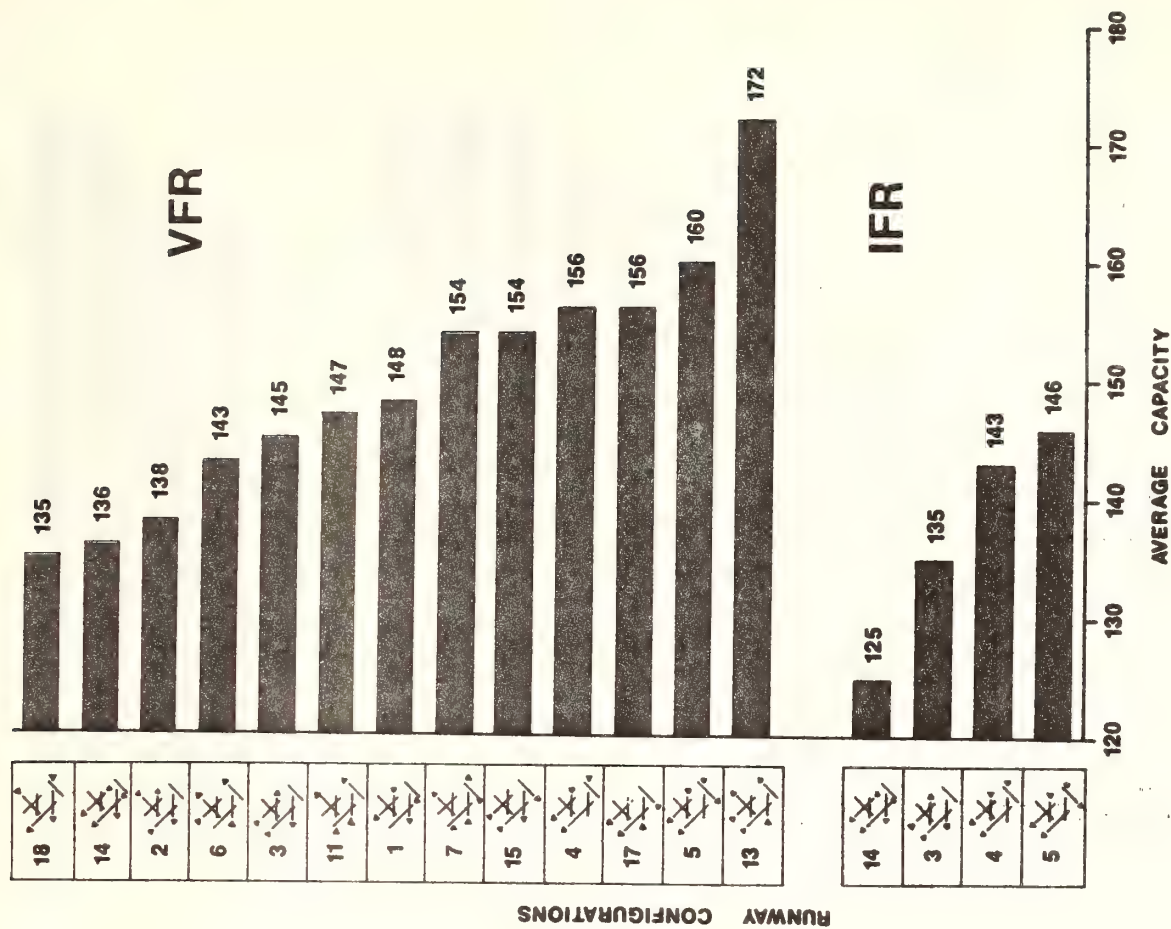


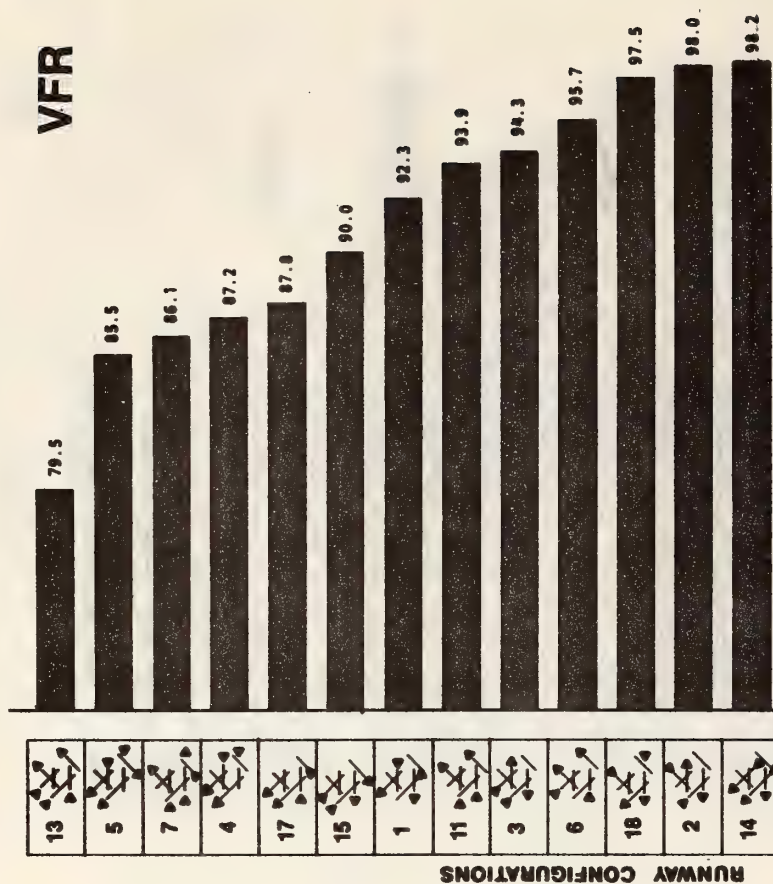
Exhibit 6  
Variation of Capacity with Percent Arrivals

The average visual flight rules (VFR) and instrument flight rules (IFR) capacities for the runway configurations illustrated were determined for conditions representative of the "average" during quota hours (3PM-8PM) at O'Hare. Current hourly demand at O'Hare is approximately 135 to 145 operations per hour during peak periods. Weighted to reflect the annual use of O'Hare's runways in the past, the average annual VFR and IFR capacities of the airspace/airfield system are 143 and 126 operations per hour, respectively. Current quota hour demand is virtually equal to the airspace/airfield system average VFR capacity and exceeds its average IFR capacity by 9 to 19 operations per hour in IFR weather conditions.

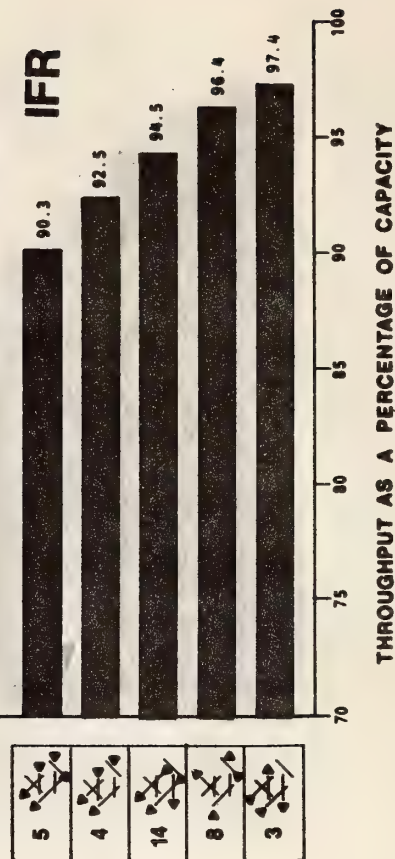


THROUGHPUT SHOULD BE USED FOR OPERATIONAL PURPOSES AS AN INDICATOR OF THE NUMBER OF MOVEMENTS TO BE EXPECTED UNDER SPECIFIED DEMAND AND CAPACITY CONDITIONS.

## VFR



## IFR



**Throughput** is the number of aircraft operations that may be processed by a runway configuration under a combination of actual demand and specific operating conditions. At practical operating levels, throughput is always less than capacity due to variations in volume and distribution of actual demand.

Although the actual throughput will tend to equal demand when the theoretical capacity is substantially greater than demand, the throughput will be less than demand when demand approaches capacity. The ease with which the different runway configurations can process a given demand is illustrated by expressing throughput as a percentage of the theoretical capacity of each configuration. Low percentages identify those configurations where the system must work less hard to maintain throughput.

Exhibit 8

Throughput/Capacity Relationships for  
Selected Runway Configurations

**Delay** is the difference between the actual time it takes an aircraft to perform an operation over a specific portion of the system and the normal time it would take to perform the same operation with no interference from other aircraft. A Task Force validated computer simulation was employed to calculate the delay characteristics of selected O'Hare runway configurations because of a lack of readily available, uniformly reported delay statistics.

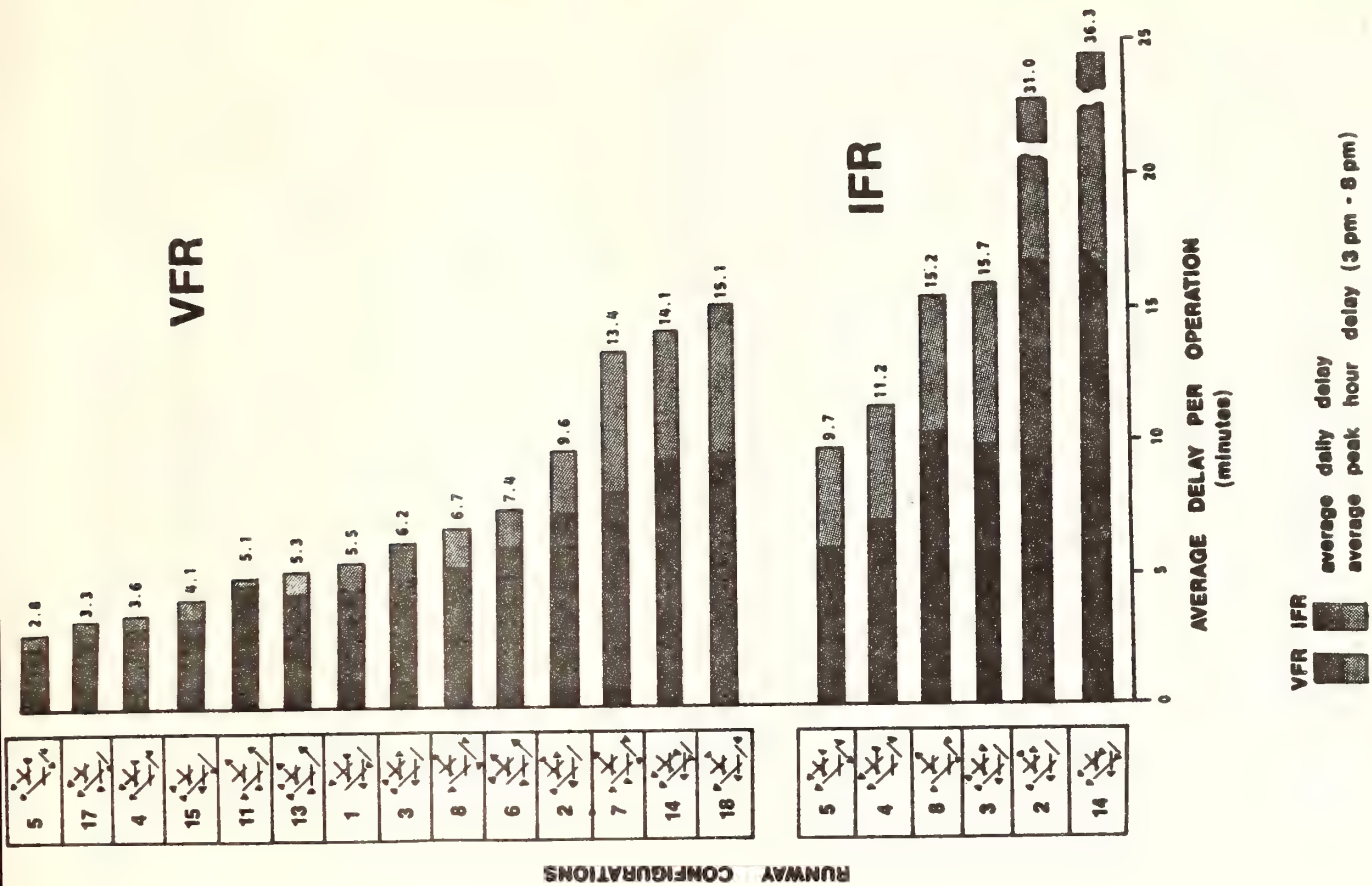


Exhibit 9

Average Daily and Peak Hour Delay For  
Selected Runway Configurations

The average relationships between throughput, capacity, and delay at O'Hare were determined. From the illustration, it may be seen that delay rises significantly as throughput approaches capacity. In essence, the delay portion of the curve indicates the efficiency with which throughput is achieved for various runway configurations. The curve also indicates the necessity for a delay-based runway configuration performance criterion. While a capacity-based criterion such as utilized in the past indicates the relative throughput capability of various runway configurations, it does not indicate the efficiency with which the throughput is achieved.

Delay is a more effective measure of system operational efficiency than is capacity. As an example, it was found that while the capacities of configurations 6 and 3 are similar at 145 and 143 operations per hour, respectively, 1.2 minutes of delay may be saved for every operation processed with configuration 6 rather than configuration 3. In this case, as in numerous others, the capacity differential between configurations does not provide an adequate definition of the efficiency with which the system processes demand. Delay does provide a measure of such efficiency; however, small differences in delay are difficult for controllers to ascertain in operational use. Nonetheless, impetus for developing a delay based runway performance criterion is given by the current annual costs of delays at O'Hare:

- \$44.3 million to aircraft operators
- 67 million gallons of fuel
- 4.6 million hours of passenger delays.

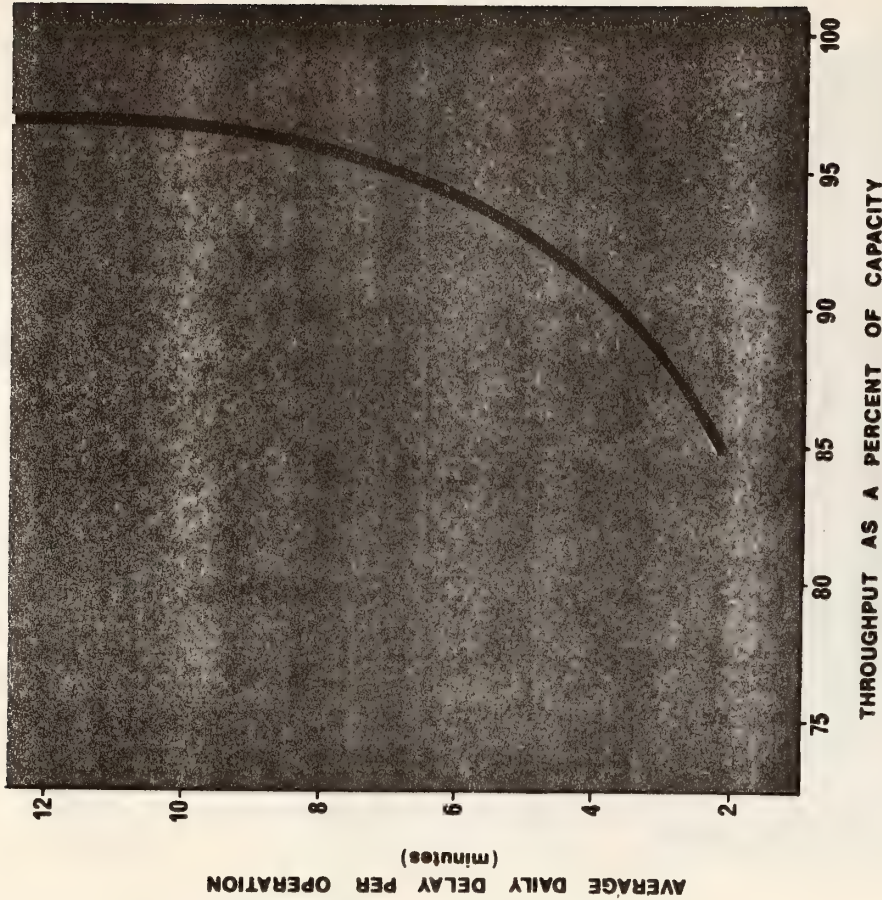


Exhibit 10

Effect of Throughput/Capacity Relationship on Delay

DELAY SHOULD BE EMPLOYED FOR JUDGING THE PERFORMANCE OF RUNWAY CONFIGURATIONS RATHER THAN CAPACITY OR THROUGHPUT.

- THE AIRLINES SHOULD DEVELOP A UNIFORM SYSTEM OF DELAY REPORTING
- THE FAA SHOULD DESIGN AND IMPLEMENT A COMPUTER BASED DELAY PREDICTING AND RECORDING SYSTEM FOR OPERATIONAL USE
- THE FAA, AIRLINES, AND CITY SHOULD CONTINUE TO APPLY QUANTITATIVE OPERATIONS ANALYSIS TECHNIQUES.

## current delay reduction options

The findings related to evaluating the potential delay reduction benefits of air traffic operating strategy, demand management and airfield facility improvement options clearly indicate there are alternative means to significantly reduce current aircraft delays at O'Hare. These options, if implemented, offer potential for continued benefit through the pre-1985 and post-1985 periods.

## air traffic operating strategy

Task Force analyses found the following with respect to air traffic operating strategy:

- Eighteen of O'Hare's currently available configurations were analyzed. The five with the least delay characteristics are capable, from a meteorological standpoint, of operating the majority of the year. Heretofore, they have been operating less than five percent annually, primarily due to airfield restrictions. Recent airfield improvements have removed these restrictions, and current experience indicates that the use of these low delay configurations has caused a noticeable trend towards decreasing the level of delay. Delay optimized selection of O'Hare's operational runway configurations can reduce delay related operating costs by \$11 million to \$16 million annually, over the delay related costs incurred with the historic pattern of runway selection.
- Configurations with three arrival runways offer high potential for inbound aircraft delay savings, particularly with judicious management of the arrival spacing on the third arrival runway during peak departure periods in order to expedite departure processing.
- A disproportionate number of configuration changes were observed to occur during or near the beginning of the quota period when system delay is extremely sensitive to minor fluctuations in demand.

OPERATE O'HARE INTERNATIONAL AIRPORT IN DELAY OPTIMAL CONFIGURATIONS EMPLOYING THE LOWEST DELAY CONFIGURATION POSSIBLE, GIVEN SPECIFIC CONDITIONS OF RUNWAY AVAILABILITY, WEATHER AND NOISE ABATEMENT POLICY.

TRIPLE ARRIVAL AND DEPARTURE RUNWAY CONFIGURATIONS SHOULD CONTINUE TO BE USED AS OFTEN AS FEASIBLE IN ORDER TO REDUCE DELAY.

DO NOT INITIATE CONFIGURATION SHIFTS IN THE 1PM TO 8PM PEAK TRAFFIC PERIOD UNLESS WEATHER OR NOISE ABATEMENT DICTATES.

There exists a need for a delay-based operational criterion predicated upon the best possible estimates of the delay consequences of operating decisions. While a capacity-based criterion such as utilized in the past indicates the relative throughput capabilities of various configurations, it does not indicate the efficiency with which the throughput is achieved. However, no uniform or real-time delay data with which to assess the consequences of day-to-day operational decisions currently exists.

Optimized management of the air traffic control system (i.e., optimized procedures to aid in selection of runway configurations) could achieve now, at minimum investment cost, savings comparable to those that will be achieved much later at much higher cost when third generation ATC hardware is deployed. This highlights the importance of FAA management exploration of opportunities for improved system efficiency by placing emphasis on optimization of operations at least equal to that given development of ATC hardware.

DEVELOP AND IMPLEMENT A MANAGEMENT PLAN WHICH WILL ENSURE THE OPERATION OF THE O'HARE AIRSPACE/AIRFIELD SYSTEM IN A DELAY OPTIMAL MANNER UNDER ALL CONDITIONS OF WEATHER, RUNWAY AVAILABILITY, NOISE ABATEMENT, ETC. THE PLAN SHOULD INCLUDE A REAL TIME SYSTEM FOR PREDICTING, MONITORING AND EVALUATING SYSTEM PERFORMANCE IN TERMS OF DELAY AND THROUGHPUT BY RUNWAY AND OVERALL SYSTEM.

INVESTIGATE THE FEASIBILITY OF A MANAGEMENT INFORMATION SYSTEM FOR THE O'HARE ATC PERSONNEL WHICH WOULD LINK THE ARTS III SYSTEM TO THE REAL-TIME SYSTEM FOR MONITORING AND CONTROLLING SYSTEM PERFORMANCE.

DEVELOP A UNIFORM AIRLINE DELAY REPORTING PROCEDURE TO PROVIDE THE FAA WITH DATA ON SYSTEM PERFORMANCE.

# management of demand

Congestion delays are due to demand and/or limited airfield capacity. This section summarizes the findings and recommendations from analyses directed towards reducing congestion delays through limiting or controlling peak demand at O'Hare.

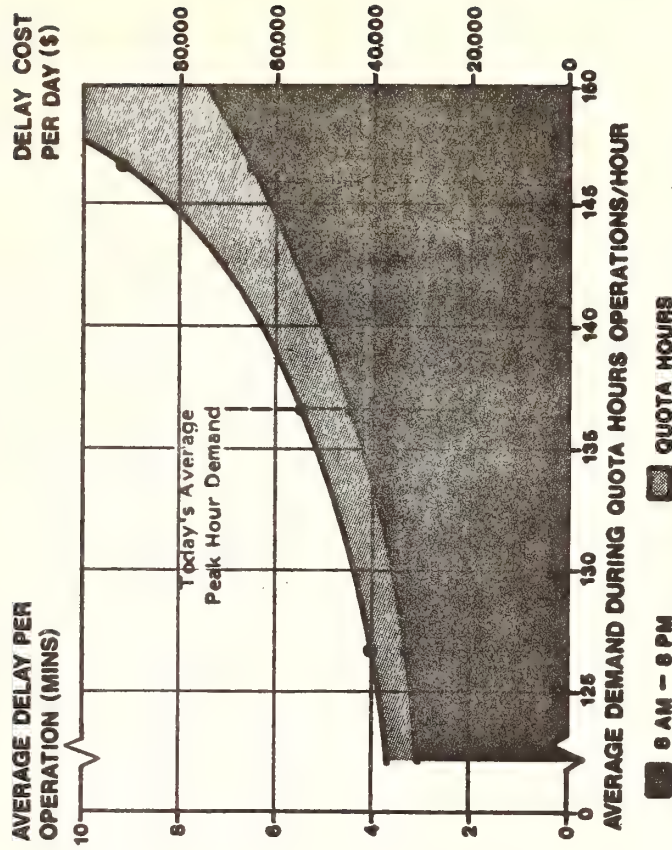


Exhibit 11  
O'Hare Delays vs. Peak Demand  
1975 VFR

Delay is quite sensitive to demand during the quota hours (3PM to 8PM) at O'Hare. In the illustration, the upper curve shows the average delay during the quota hours at O'Hare and the lower curve shows the average delay during the whole day. An increase in demand of 10 operations per hour, from 137 to 147, would increase the average delay during the quota hours by more than 60 percent under VFR weather conditions. The addition of only a single operation at the 137 level raises the total system delay costs by at least \$300. The addition of five operations above the 137 level would raise the total system costs by at least \$2,000,000 annually, not including the multiplicative effect of severe delay days.

STRICTLY ENFORCE THE EXISTING FAR 93 QUOTA RULE AND ELIMINATE NON-RESERVATION TRAFFIC IN IFR WEATHER CONDITIONS.  
REVISE CURRENT PROCEDURES FOR ACCEPTING VFR ARRIVALS TO THE TERMINAL AREA, RECOGNIZING THE FULL COST OF THESE ADDED OPERATIONS.  
THE PRESENT PRACTICE OF ACCEPTING VFR ARRIVALS WHEN DELAYS ARE APPROACHING 15 MINUTES SHOULD BE DISCONTINUED UNLESS SUCH TRAFFIC CAN BE ACCOMMODATED ON NON-INTERFERING RUNWAYS.  
DEVELOP A MEANS TO ACCURATELY ASSESS SYSTEM DELAY AND TO MONITOR AIRCRAFT RESERVATIONS.

Based on historical data, severe delay days may be expected to interrupt O'Hare operations during 75 days annually. These severe delay days are caused by system disruptions resulting from:

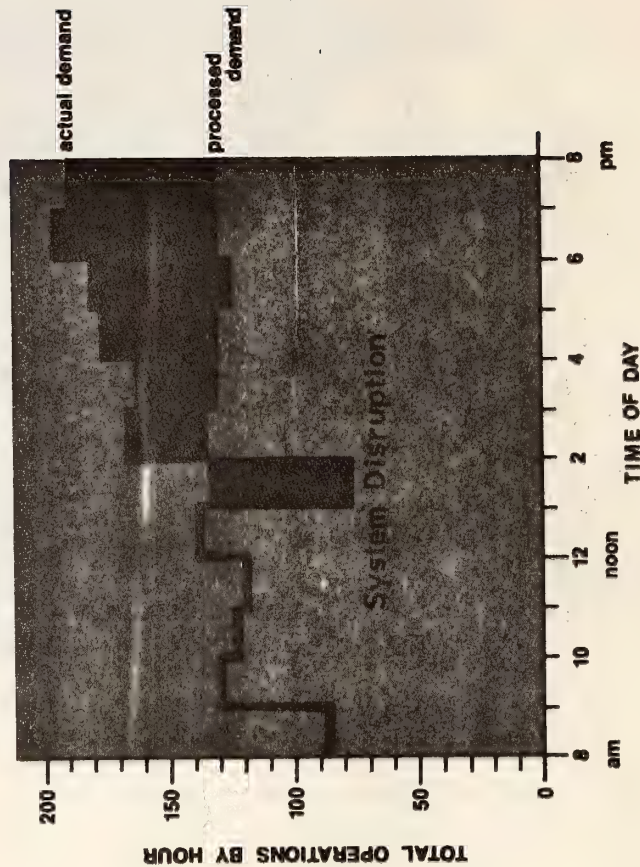
- weather
- navigational aid malfunctions
- runway closures due to disabled aircraft
- runway closures due to construction and maintenance
- etc.

Analyses of the effect of severe delay days found that a reduction in capacity for even 30 minutes to 1 hour during peak periods, can cause substantial backlog and lengthy delays to all flights over an extensive time period following the initial disruption. Based on past operations, severe delay days at O'Hare increase the cost of delay by \$8.3 million annually.

DEVELOP AN EFFECTIVE AND EQUITABLE PLAN FOR CONSOLIDATION OR CANCELLATION OF AIRLINE AND OTHER FLIGHTS DURING SHORT TERM REDUCED CAPACITY CONDITIONS AT O'HARE.

REFINE THE PROCEDURES FOR CONTROLLING TRAFFIC FLOW INTO THE O'HARE TERMINAL SYSTEM UNDER CONDITIONS OF SEVERE DELAY.

PHASE, SCHEDULE AND FULLY COORDINATE AIRFIELD CONSTRUCTION TO MINIMIZE ITS IMPACT ON DELAY.



Significant delay savings can be realized by both demand volume and pattern changes if they can be achieved without compromising the airport's connecting functions.

- A build-up in total airport demand was observed in the hours directly preceding the 3PM quota hour. Elimination of this pre-quota hour "bulge" in demand and strict adherence to the 135 movement level by revision, extension, and enforcement of the FAR Part 93 "quota rule" could result in aircraft operating delay cost savings of \$4,000,000 annually.
- Changing today's 60 minute quota period to a 30 minute quota period, in order to depeak hourly demand, could result in aircraft operating delay cost savings of \$5,000,000 annually.
- Establishment of an arrival/departure balancing quota could result in aircraft operating delay cost savings of \$2,500,000 annually.

While the delay reduction benefits of adjustments to the O'Hare demand pattern appear attractive, the costs associated with such changes may have far reaching impacts on national air transportation system efficiency. The high volume and directional peaking characteristics of scheduled air carrier demand at O'Hare, to a great extent, are due to the airport's connecting role (approximately 50 percent of annual enplanements at O'Hare are connections). Analysis of the implications of demand pattern changes on the connecting complex of flights at O'Hare was beyond the scope of this study.

GIVEN CAB APPROVAL, THE AIRLINES AND FAA SHOULD ASSESS THE COSTS OF CHANGES IN THE LEVEL AND DISTRIBUTION OF DEMAND AS A BASIS FOR RE-EVALUATION OF AIRLINE SCHEDULING POLICY AND/OR ADJUSTMENT OF THE CURRENT QUOTA REGULATION. DETERMINE THE FEASIBILITY OF ESTABLISHING:

- EXTENDED QUOTA HOURS
- INTRAHOUR QUOTAS
- ARRIVAL/DEPARTURE QUOTAS

THE FAA AND AIRLINES SHOULD DETERMINE THE FEASIBILITY OF INCLUDING EXTRA SECTIONS UNDER THE QUOTA.

Two observations were made from the empirically derived relationships between demand and delay under the assumptions of existing air traffic control rules and procedures.

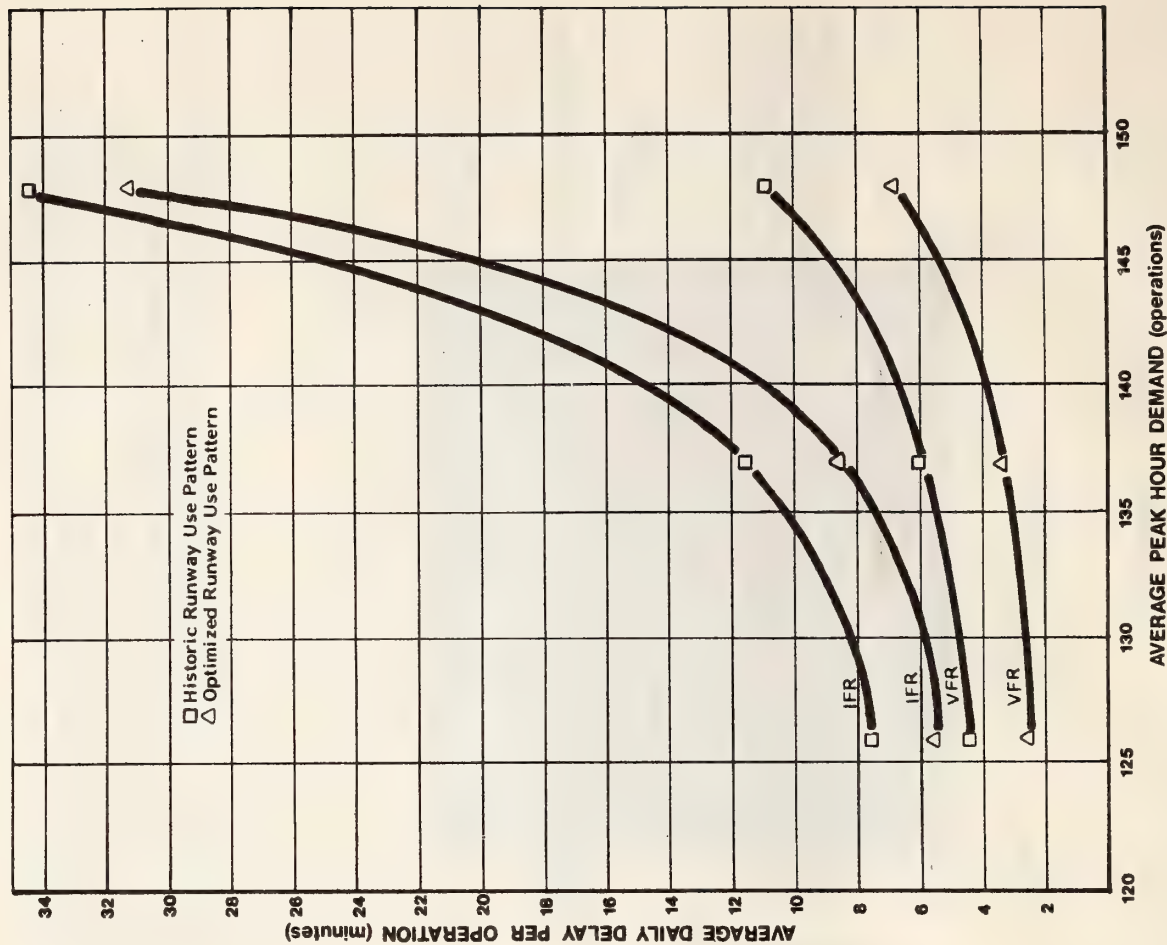
- Delays during IFR weather are significantly greater than delays in VFR weather under any scheduled level of demand investigated.
- As the delay optimized runway use pattern recommended by the Task Force is increasingly utilized, the potential will exist to:
  - decrease today's average VFR and IFR delays by 2 to 3 minutes per operation at the current activity level, or
  - increase the average hourly activity level by approximately 4 to 5 operations without increasing delay levels over those experienced today.

There is potential for increased capacity at O'Hare with the facilities available by the optimization of runway use; however, operation at a higher volume of activity would decrease the delay reduction benefits identified in this study. The extent to which available additional capacity should be employed for delay cost reduction or for demand increases and the timing of such actions is beyond the scope of this study.

The important fact, which the curves demonstrate, is that delay in IFR weather is significantly greater than that in VFR and is extremely sensitive to increases in demand. Planning the future increases in scheduled activity should give careful consideration to the range of IFR delays.

Exhibit 13  
Delay vs. Demand  
Existing System

THE AIRLINES AND FAA SHOULD CONSIDER A SEASONAL (2 LEVEL) QUOTA BASED UPON THE PREDOMINANT SEASONAL DELAY CHARACTERISTICS OF THE AIRFIELD. SUCH A QUOTA COULD PROVIDE FOR A HIGHER VOLUME OF ACTIVITY DURING GOOD WEATHER MONTHS.



## airfield improvements

Several minor airport development options were found to offer effective means to reduce delay.

- A new runway 22R angled exit would be justified by an annual use of 2 to 3 percent; a 12 percent use would yield a \$750,000 savings annually. Similar benefit can be derived from construction of a new angled exit on runway 14L.
- Inbound aircraft in the existing arrival holding area (penalty box) conflict with 32L, T1 departure queues creating a ground control problem during the operation of certain low delay configurations. Relocation of this apron in the immediate D, E, F concourse area should be investigated in order to facilitate the increased controller use of these desirable configurations.
- An additional hold apron to better serve the H and K concourse gates is needed. Not only would a new apron add needed arrival hold capacity, but also would reduce the need for relocation of the existing penalty box by providing suitable alternate holding areas when certain low delay configurations are in use.

These development options will enhance the configuration selection options available to the controllers and facilitate the use of low delay configurations by reducing controller ground handling difficulties associated with several key configurations.

CONSTRUCT ADDITIONAL RUNWAY EXITS:

- ON RUNWAY 22R BETWEEN THE INTERSECTION WITH RUNWAY 9L/27R AND THE 14L PARALLEL TAXIWAY.
- ON RUNWAY 14L BETWEEN THE INTERSECTION WITH RUNWAY 18/36 AND THE INTERSECTION WITH RUNWAY 9L/27R.

INVESTIGATE RELOCATION OF THE EXISTING ARRIVAL HOLDING APRON IN THE IMMEDIATE D, E, F CONCOURSE AREA.

DETERMINE THE LOCATION FOR AND CONSTRUCT AN ADDITIONAL INBOUND AIRCRAFT HOLDING APRON TO SERVE AIRCRAFT IN THE H AND K CONCOURSE AREA.

## future atc technology

Six proposed FAA engineering and development elements have the potential to affect future operations at O'Hare. These elements are:

- Wake Vortex Advisory/Avoidance System (WVAS)
- Upgraded Automation — Including Metering and Spacing (M&S) and automation aids to the controller
- Discrete Address Beacon System (DABS)
- Airport Surface Traffic Control (ASTC) System
- Area Navigation (RNAV)
- Microwave Landing System (MLS)

For a further description of the FAA engineering and development program, the reader is referred to Volume II, Chapter 5, of this study.

The two elements of the FAA's engineering and development program which are foreseen to have a major impact on O'Hare capacity and delay are:

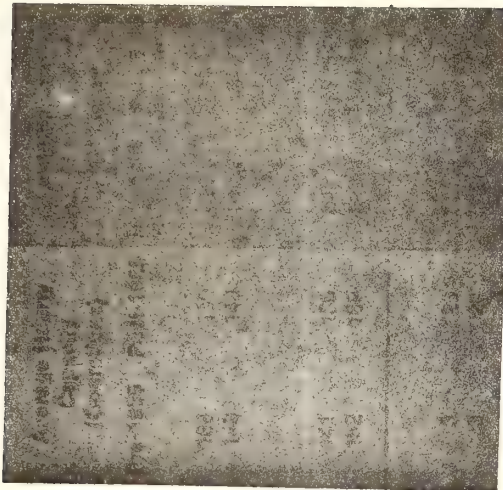
- Wake vortex advisory/avoidance system (WVAS)
- Upgraded ATC automation in the form of automated aircraft metering and spacing

Their impact was studied through identification of the capacity increase and delay decrease benefits achieved by reduced longitudinal separation standards on final approach and increased delivery accuracy predicted by FAA E&D program managers, based upon estimates of the most probable future demand and ATC equipment scenarios.

Upgraded automation and WVAS were found to offer significant capacity increase and delay reduction benefits in the pre-1985 and post-1985 periods. The study findings included the following with regard to O'Hare capacity and delay in the future ATC environment:

- Without proposed ATC improvements, O'Hare's capacity will continue to deteriorate through the post-1985 period and the cost of delay will escalate due to the projected increase in heavy jet aircraft.
- Measured against conditions which will occur if no ATC improvements are undertaken, the potential net delay savings of the proposed future ATC system elements are substantial, ranging from \$13,000,000 to \$46,700,000 annually in future periods.

It was also concluded that optimized runway configuration selection continues to provide significant capacity and delay benefits through the post-1985 period. Essentially, each of the delay reduction actions-ATC procedural, airport use policy, and airport development options-found to be beneficial in the current and near-term, will continue to provide significant delay reduction benefit regardless of the future ATC equipment environment.



#### **No ATC Improvements (Do Nothing)**

- Historic Runway Use
- Optimized Runway Use

#### **Most Probable ATC Equipment Improvements**

- Historic Runway Use
- Optimized Runway Use

#### **Net Benefit of ATC Improvements Versus "Do Nothing"**

- Historic Runway Use
- Optimized Runway Use

**TABLE 1**

### **CAPACITY AND DELAY COST COMPARISON NO ATC IMPROVEMENTS VS. MOST PROBABLE PRE AND POST-1985 ATC EQUIPMENT**

PROCEED WITH HIGHEST PRIORITY ON THE DEVELOPMENT AND INSTALLATION OF WAKE VORTEX AND METERING AND SPACING EQUIPMENT. REASSESS THE TIMETABLE OF OTHER PROGRAM ELEMENTS, IF NECESSARY, TO GIVE HIGHEST PRIORITY TO WAKE VORTEX AND METERING AND SPACING PROGRAMS.

Of concern is the finding that in the FAA engineering and development estimates supplied to the Task Force, the benefits to be derived from the wake vortex advisory/avoidance system with its reduced intrail aircraft separations are heavily dependent upon the upgraded automation element of the engineering and development program. The metering and spacing function appears to be technically complex and consequently most vulnerable to implementation schedule slippage. It is imperative that manual wake vortex ATC procedures be implemented as soon as possible to allow reduced separations when wake vortex is not critical. Present test equipment installation may allow limited implementation at O'Hare during 1976. Further, it is recommended that the FAA proceed with highest priority on the development and installation of wake vortex and metering and spacing equipment at O'Hare. The FAA also should reassess the timetable of other program elements, if necessary, to give highest priority to wake vortex and metering and spacing programs.

IMMEDIATELY IMPLEMENT PROCEDURES TO ACHIEVE REDUCED INTRAIL SEPARATION UNDER METEOROLOGICAL CONDITIONS WHICH ELIMINATE WAKE VORTEX IMPACT.

- INITIATE A STUDY TO IDENTIFY THE ENVIRONMENTAL IMPACT OF REDUCED SEPARATIONS SO THAT OPERATIONAL IMPLEMENTATION IS NOT DELAYED.
- REVIEW WITH ALL FLIGHT PERSONNEL THE CRITICAL IMPORTANCE OF REDUCING SEPARATIONS UNDER CONDITIONS IN WHICH WAKE VORTICES ARE NOT PRESENT.
- IMPLEMENT REDUCED SEPARATIONS UNDER KNOWN SAFE CONDITIONS AS DEFINED IN PREVIOUS TESTING PROGRAMS.
- IDENTIFY AND PROGRAM FUNDS TO MODIFY AND EXTEND THE WWAS TEST EQUIPMENT TO ALLOW FOR OPERATIONAL USE.

Insufficient information was provided to the Task Force to fully identify any capacity and delay benefits for program elements other than WWAS and upgraded automation. However, a review of these other engineering and development program elements found that the ASTC program, which will provide discrete aircraft identity to the ground controller and airborne coverage near the airport, appears to have the potential to enhance runway configuration selection options in periods of low ceiling and visibility. Such equipment improvements will increase O'Hare's IFR capacity and greatly reduce IFR delays.

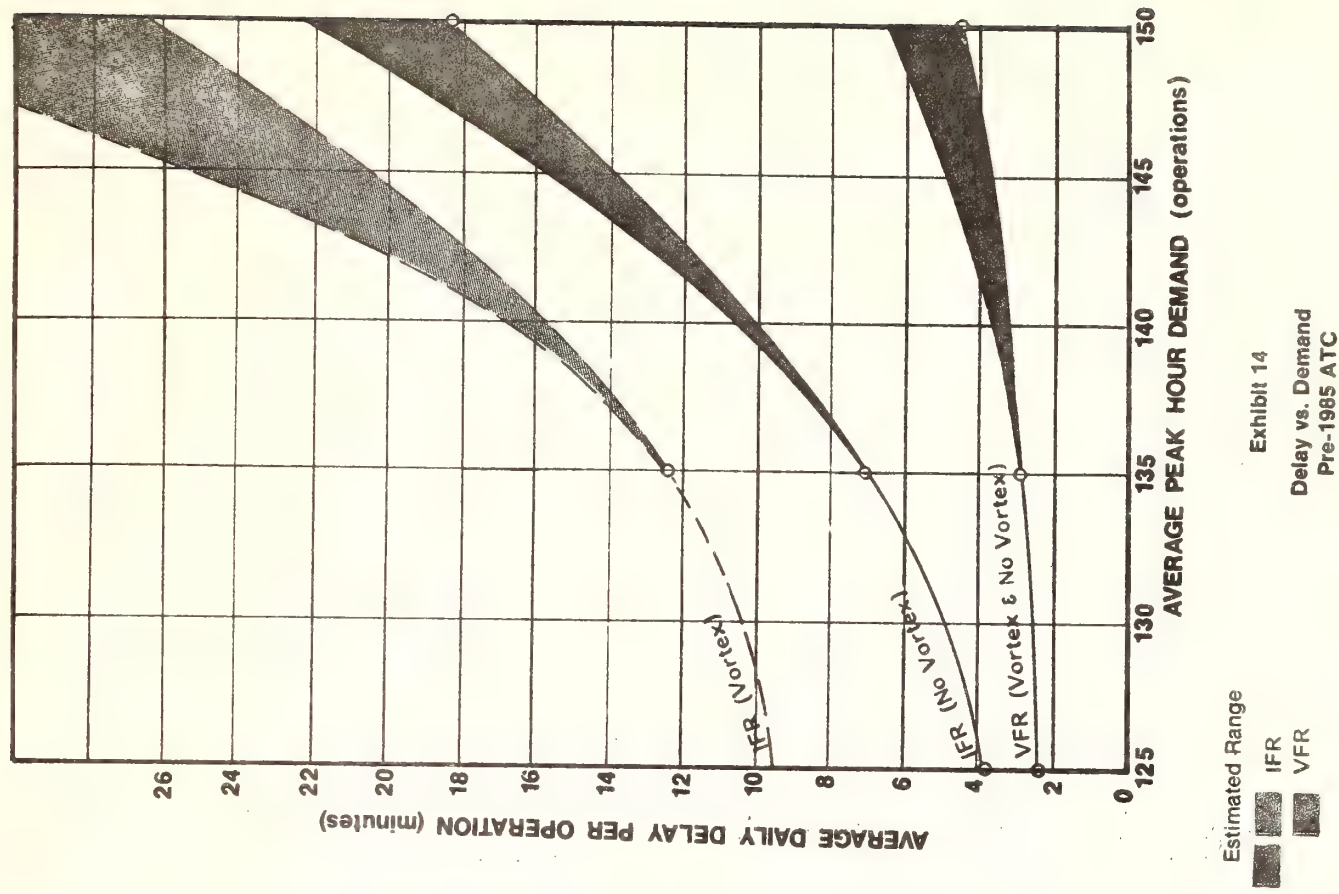
INCREASE THE DEVELOPMENT EFFORT FOR THE ASTC PROGRAM, INCLUDING ASDE AND AIRCRAFT IDENTITY TAGS, WHICH APPEARS TO OFFER THE POTENTIAL FOR INCREASING O'HARE'S IFR CAPACITY AND REDUCING DELAY THROUGH ENHANCED CONFIGURATION SELECTION OPPORTUNITIES.

## demand/delay relationships

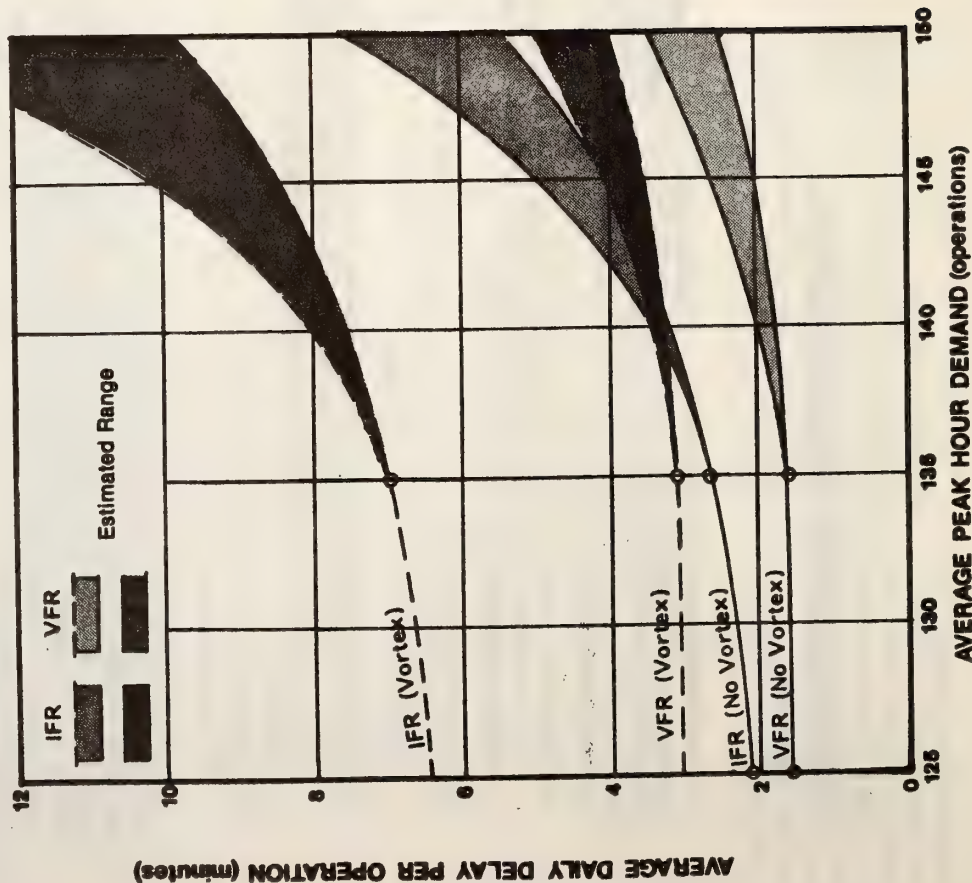
Future demand/delay relationships will be more complex than at present, consisting of different ATC operating procedures not only for VFR and IFR weather but also for wake vortex and non-wake vortex conditions. The relationships between demand and delay were determined for both the pre-1985 and post-1985 time periods. The study findings are listed below:

- The volume of scheduled aircraft operations will have a significant influence on future O'Hare delay costs; the system performance appears less sensitive to fleet mix changes than to fleet volume changes.
- If the level of scheduled demand at O'Hare is increased significantly, levels of delay greater than today's will be experienced unless there is a reduction in separation provided by future ATC equipment.
- As the percentage of heavy aircraft in the fleet increases, levels of delay greater than today's will be experienced at the current level of scheduled demand, without a reduction in separation standards afforded by improved ATC equipment.
- Under pre-1985 ATC equipment assumptions, delays will increase as a function of the maximum hourly operations scheduled.

The relationships shown in the Exhibits indicate that with pre-1985 and post-1985 ATC equipment improvements the existing O'Hare airfield/airspace system will be capable of processing increased numbers of passengers through the post-1985 planning period. In pre-1985, seat capacity increases appear possible through volume increases in VFR weather and additional concentration of heavy aircraft during peak demand hours. In the post-1985 environment, both increased volume and increased heavy aircraft concentrations appear possible at near current delay levels in all weather conditions.



The potential for increased future traffic volumes at O'Hare is realizable only if cost-effective solutions are found to landside facility constraints such as access roadway limitations, vehicular parking restrictions, and inadequate terminal building space and equipment. Concentrated airlines/city action must be taken to find creative means to eliminate the landside constraints and to mitigate the local environmental consequences of O'Hare operations and development if these future benefits are to be achieved. Included in the actions required, is a clear determination of the future role of Midway Airport in order to provide a meaningful basis for resolution of an O'Hare development program.



THE O'HARE MASTER PLAN STUDY SHOULD INCLUDE DETAILED EVALUATIONS OF FUTURE DEMAND/DELAY RELATIONSHIPS, LANDSIDE FACILITY EXPANSION, AND ENVIRONMENTAL IMPACT.

- REASSESS AND FULLY QUANTIFY FUTURE O'HARE DELAY PERFORMANCE GIVING CONSIDERATION TO OPERATING EXPERIENCE WITH THE WAKE VORTEX ADVISORY SYSTEM AND LATEST SEPARATION CRITERIA FOR THE PURPOSE OF MORE DEFINITIVE AIRPORT AND SCHEDULE PLANNING.
- INVESTIGATE MEANS TO ACHIEVE EXPANSION OF EXISTING GATE, TERMINAL FACILITY AND GROUND SIDE SYSTEM CAPACITY, INCLUDING AIRPORT ACCESS ROADWAYS.

# ACTION PLAN

The previous sections have summarized the major findings, conclusions and recommendations of the O'Hare Delay Task Force Study. Implementation of many of the potentially effective delay reduction actions identified will require further intensive effort and action on a joint or individual basis by group participants. This section presents an action plan which identifies the type of action recommended, the action priority, and the agency responsible for initiation of follow-through. If implemented, the action plan outlined will result in the delay savings described throughout this report. The action plan identifies four types of actions as follows:

- **Implementable Items** — Changes or improvements whose benefits have been clearly identified and do not necessitate a major policy change by any of the study participants.
- **Major Policy Items** — Changes in procedural or regulatory environment requiring major policy changes by one or more study participants.
- **Master Plan Study Items** — Physical improvements whose delay reduction merits must be assessed giving consideration to the full environmental and economic consequences.
- **Air Traffic Control System Items** — Improvements whose character requires that they be system-wide in application, necessitating further evaluation and/or research and development by the Federal Aviation Administration.

The time frame for each item of the action plan along with a recommendation for the lead responsibility for follow-through on each item are indicated in the tabulation which immediately follows. The elements in each group are listed in order of recommended implementation priority. It is stressed that the responsibilities shown provide identification of the lead-agency in the most appropriate position to initiate action on each item; with few exceptions all groups will be required to actively participate in accomplishing each action.

## RECOMMENDED ACTION PLAN

| ACTION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | TIME FRAME |              |            | LEAD AGENCY |          |      | VOLUME II SECTION                            |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|--------------|------------|-------------|----------|------|----------------------------------------------|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Short      | Intermediate | Long Range | FAA         | Airlines | City |                                              |
| <ul style="list-style-type: none"> <li>• Operate in Delay Optimal Configurations</li> <li>• Enforce Existing FAR 93 Quota Rule</li> <li>• Develop a Uniform Airline Delay Reporting Procedure</li> <li>• Phase and Schedule Airfield Construction to Minimize Delay</li> <li>• Minimize Configuration Shifts in Peak Demand Periods</li> <li>• Install Centerline Lights on Runway 9R/27L</li> <li>• Construct Additional Exits on Runways 22R and 14L</li> <li>• Determine Location for and Construct Inbound Hold Apron</li> <li>• Investigate Procedures for Interairline Ramp Coordination</li> <li>• Segregate GA and Air Taxi Operations When Practical</li> </ul>                                                                                                                                                                                                   |            |              |            |             |          |      | 4.1.5<br>3.3.6.2                             |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |            |              |            |             |          |      | 4.2.3<br>3.3.5<br>4<br>4.3.1<br>4.3.2        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |            |              |            |             |          |      | 3.3.2                                        |
| <ul style="list-style-type: none"> <li>• Develop and Implement an Airspace/Airfield Management Plan</li> <li>• Determine the Feasibility of Establishing                             <ul style="list-style-type: none"> <li>- Extended quota hours</li> <li>- Intrahour quotas</li> <li>- Arrival/departure quotas</li> <li>- Revised procedures for accepting VFR arrivals</li> <li>- Inclusion of airline extra sections under quota</li> </ul> </li> <li>• Investigate A Two Level Quota Matching Demand to O'Hare's Seasonal IFR and VFR Capacity</li> <li>• Develop a Plan to Consolidate or Cancel Flights During Anticipated Conditions of Reduced Capacity at O'Hare</li> <li>• Obtain Waiver for Arrivals on 14R and 14L Independent of Departures on Runways 27L-9R and 27R-9L.</li> <li>• Employ Quantitative Techniques in all Future Planning Work</li> </ul> |            |              |            |             |          |      | 4.1<br>4.2.1<br>6.1<br>3.4<br>3.3.3<br>4.2.3 |

# RECOMMENDED ACTION PLAN

| ACTION                                                                                                      | TIME FRAME |              |            | LEAD AGENCY |          |      | VOLUME II SECTION |
|-------------------------------------------------------------------------------------------------------------|------------|--------------|------------|-------------|----------|------|-------------------|
|                                                                                                             | Short      | Intermediate | Long Range | FAA         | Airlines | City |                   |
| • Investigate Reconfiguration of Runway Intersections                                                       |            |              |            |             |          |      | 3.3.3             |
| • Investigate Relocation of Existing Penalty Box                                                            |            |              |            |             |          |      | 4.3.2             |
| • Investigate Means to Achieve Gate Expansion                                                               |            |              |            |             |          |      | 3.5               |
| • Investigate Alternate Terminal Facility Expansion                                                         |            |              |            |             |          |      |                   |
| • Consider Construction of Maintenance Runways                                                              |            |              |            |             |          |      | 3.4               |
| • Consider Construction of General Aviation Runways                                                         |            |              |            |             |          |      | 3.3.2             |
| • Explore Full Use at the Inner Circular Taxiway for B-747 Aircraft                                         |            |              |            |             |          |      | 4                 |
| • Define Groundside System Constraints/Potential Solutions                                                  |            |              |            |             |          |      |                   |
| • Reassess Future Demand/Delay Relationships for O'Hare's Major Configurations                              |            |              |            |             |          |      | 6                 |
| • Implement Manual Wake Vortex ATC Procedures                                                               |            |              |            |             |          |      | 5.3.4             |
| • Increase Effort on Wake Vortex and Metering and Spacing Equipment. Reassess Timetable for ATC Development |            |              |            |             |          |      | 5.3.4             |
| • Conduct Airspace Analysis to Determine Interaction Between O'Hare, Midway and Other Chicago Area Airports |            |              |            |             |          |      | 3.3.1             |
| • Refine the Flow Control Procedures for Controlling O'Hare Traffic Under Anomalous Demand                  |            |              |            |             |          |      | 3.4               |
| • Investigate the Feasibility of an ARTS III Based Delay Management Information System                      |            |              |            |             |          |      | 4.1               |
| • Increase Development Effort for ASTC Program                                                              |            |              |            |             |          |      | 5.6.1             |





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